EXHIBIT A

Living Resources

Appendix H

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Living Resources
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LIVING RESOURCES

Introduction

The offshore area of the Columbia River is a highly productive biological environment that is influenced by a variety of complex physical processes. The major short-term processes that affect the area include tides and, secondly, local winds and currents. River flow also has a major seasonal impact on the area, the extent of which depends on the volume of flow.

During periods of high river flow in the spring, the area directly off the mouth is influenced more by river flow and tidal cycles than by oceanic conditions. In the area of the river plume, water temperature, salinity and percent of light transmission are correlated with the tidal cycle. During ebb tide, water temperature is higher, and salinity and percent of light transmission are lower. During flood tide the reverse is true.

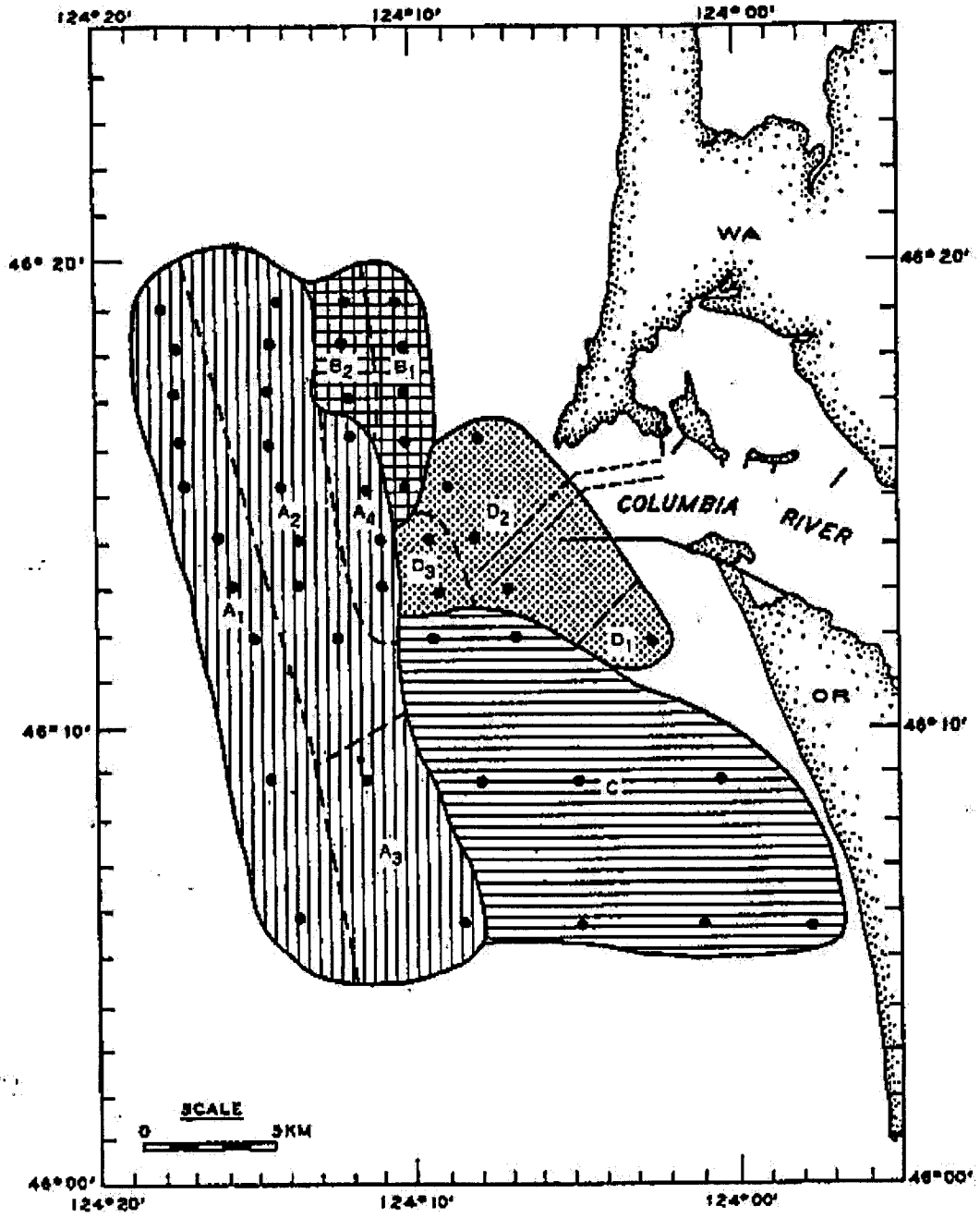
High river flow produces river induced upwelling of bottom ocean waters at both ebb and flood tide, though the effects differ. During flood tide, the river-induced upwelling entrains nutrient poor bottom waters to the surface, which produces low nutrient concentrations at the surface. During ebb tide, this effect is reduced and nutrients are more evenly distributed in the water column. Generally during high river flow, overall productivity is higher during the flood tide than during ebb tide.

During low flow in the Columbia (late August), the area immediately south of the mouth is affected more by river flow than during the high flow period. This is likely due to the river having lesser force, causing the river plume to spread out closer to shore. Productivity is directly correlated with the tidal cycle. High productivity and salinity occur during flood tide. Low productivity occurs during ebb tide when low productivity bottom water is entrained on the surface as a result of river-induced upwelling. During the transition period (October), local winds and currents cause nearly complete mixing of the water column. Few tidal and river induced effects are apparent.

Benthic Invertebrates

Richardson et al., (1977) performed a widespread benthic survey that described five major species assemblages of benthic invertebrates in the offshore area of the Columbia River (Figure A-1). Assemblage A (includes subassemblages1-3), the furthest offshore, was located in 60 to 97 meters (m) of water. The density of benthic invertebrates collected in assemblage A ranged from 2,000 to 12,000 organisms per square meter (m^2). The most abundant invertebrates were the clam *Axinopsida serricata,* and to a lesser extent the polychaete worms *Lumbrineris luti* and *Myriochele oculata,* and the clam *Acila castrensis.*

Figure A-1 – Benthic Assemblages and Station Groups (Richardson et al., 1977)



Assemblage B (includes subassemblages1 and 2) was located in moderate depths (29 to 44 m). The density of organisms ranged from 944 to 6,962 individuals/m^2. Dominant species were the cumacaen *Diastylopsis dawsoni,* and to a lesser extent the sea cucumber *Paracaudina chilensis,* the polychaete worm *Haploscoloplos elongatus,* and the clam *Tellina modesta.*

Assemblage C was located in shallow water (18 to 47 m) south of the main channel. The density of organisms was generally low, ranging from.334 to 888 individuals/m^2. Dominant species were the polychaete worm *Spiophanes bombyx* and the amphipod *Eohaustorious sencillus.* Also common were the polychaete worms *Magelona sacculata* and *Chaetozone setosa* and the brittle star *Amphiodia periercta-urtica.*

Assemblage D (includes subassemblages1-3) was located directly off the mouth of the Columbia in shallow water (13 to 40 m). The density of organisms was also low, ranging from 196 to 780 individuals/m^2 with the higher values at the deeper stations. Dominant species were characteristic of a mobile sand community and included the snail *Olivella pycna*, the polychaete worm *Magelona sacculata*, the cumacean *Diastylopsis dawsoni*, the amphipoda *Monoculodes spinipes,* and the snail *Olivella biplicata.*

Assemblage E (not pictured in Figure A-1) was located along the north side of the navigation channel in 13 to 20 m of water. The dominant species was the polychaete worm *Spio filicornis*, accounting for 60 percent of individuals at inshore stations. The amphipods *Hippomedon denticulatus*, *Mandibulophoxus unicirostratus* and *Monoculodes spinipes,* and the cumacean *Diastylopsis dawsoni* were also common particularly at the stations further offshore.

In July 1992, benthic invertebrate samples were collected at 51 stations offshore (Figure A-2) of the Columbia River (Hinton and Emmett, 1994). The survey produced 338 different organisms, and the number of taxa per station ranged from 11 to 130. Densities ranged from 844 to 369,462 organisms/m^2 (TableA-1). Diversity was generally high at most stations, with most values greater than 2.50. As shown in Table A-1, the three most abundant taxa within each major group found throughout the area included the polychaetes *Spiophanes bombyx*, *Spiochaetopterus costarum*, and *Owenia fusiformis;* the molluscs Mytilidae, likely juveniles, *Siliqua* spp., and *Macoma* spp.; and the crustaceans *Diastylopsis spp.*, *Diastylopsis dawsoni*, and *Diastylopsis tenuis.*

In July 1993 and August 1994, benthic invertebrate samples were collected at 28 and 29 stations offshore (Figure A-3), respectively (Emmett and Hinton, 1995; Hinton and Emmett, 1996). For the July 1993 survey, 361 different taxa were identified, with an average of 107 taxa per station. Overall densities averaged 8,768-organisms/ m^2. Diversity was generally high at most stations, with most values greater than 3.50. As shown in Table A-2, the three most abundant taxa within each major group included the polychaetes *Prionospio lighti*, *Spiochaetopterus costarum*, and *Magelona* spp.; the molluscs *Nitidella gouldi*, *Tellina* spp., and Axinopsida serricata; and the crustaceans *Diastylopsis* spp., *Diastylopsis tenuis, and Euphilomedes carcharodonta.* Polychaetes

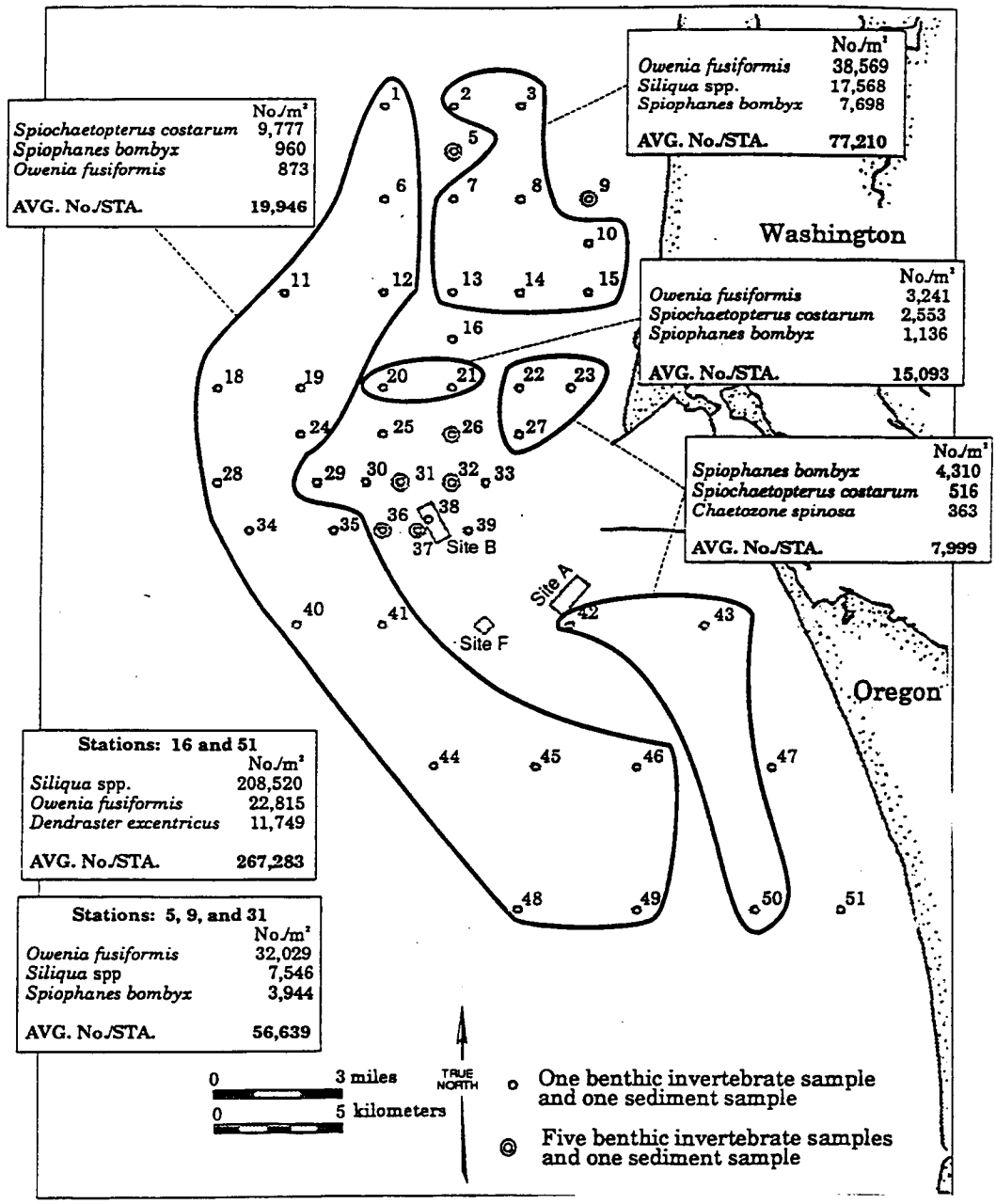


Figure A-2. Benthic invertebrate station groupings, identified using cluster analysis and their major taxa, offshore from the Columbia River, July 1992. Sites A, B, and F are ocean dredged-material disposal sites. Average number/station (AVG.No./STA.) includes all taxa. (From: Hinton and Emmett, 1994).

Table A-1 – Dominant Benthic Invertebrates, July 1992 (all stations)

Taxon	mean number/m^2
Nemertea	251
Polychaeta	
Pholoe minuta	152
Phyllodoce hartmanae	164
Nephtys spp.	130
Nephtys caecoides	112
Glycinde armigera	246
Onuphidae	134
Lumbrineris luti	122
Orbiniidae	160
Polydora brachycephala	131
Prionospio lighti	153
Spiophanes bombyx	3,233
Spiophanes berkeleyorum	570
Magelona longicornis	114
Magelona sacculata	138
Trochochaeta multisetosa	161
Spiochaetopterus costarum	3,159
Chaetozone spinosa	163
Heteromastus filobranchus	210
Mediomastus spp.	341
Owenia fusiformis	11,498
Miscellaneous	1,156
TOTAL	22,247
Mollusca	
Spiromoellaria quadrae	90
Olivella pycna	132
Acila castrensis	141
Mytilidae	966
Axinopsida serricata	185
Siliqua spp.	9,016
Macoma spp.	550
Miscellaneous	380
TOTAL	11,460
Crustacea	
Euphilomedes carcharodonta	112
Diastylopsis spp.	456
Diastylopsis dawsoni	230
Diastylopsis tenuis	350
Ampelisca macrocephala	55
Photis macinerneyi	125
Rhepoxynius spp.	63
Rhepoxyntus daboius	60
Rhepoxynius vigitegus	70
Miscellaneous	402
TOTAL	1,923
Miscellaneous	523
TOTAL FOR SURVEY	36,404

were the most abundant, averaging 4,777 organisms/m^2 and molluscs were the least abundant.

For the August 1994 survey, 337 different benthic invertebrate taxa were identified, and the number of taxa per station averaged to 105. Overall densities averaged 13,242 organisms/m^2. Diversity was high (> 3.50) at 21 of the 29 stations. As shown in Table A-2, the three most abundant taxa within each major group included the polychaetes *Owenia fusiformis*, *Prionospio lighti*, and *Spiochaetopterus costarum;* the molluscs Siliqua spp., *Axinopsida serricata* and Olivella pycna; and the crustaceans *Diastylopsis* spp., *Diastylopsis tenuis, and Leucon* spp. Polychaetes were the most abundant, averaging 7,362 organisms/m^2 and molluscs were the least abundant.

In October/November 1995 and June 1996, benthic invertebrate samples were collected at 36 and 39 stations offshore (Figure A-4 and Tables A-3), respectively (Hinton, 1998). During the 1995 survey, 571 different taxa were identified, and the number of taxa per station averaged 154. Overall densities averaged 13,903 organisms/m^2. Diversity was high,(≥ 3.50) at 31 of 36 stations. As shown in Table A-3, the three most abundant taxa within each major group included the polychaetes *Owenia fusiformis*, *Mediomastus* spp., and *Prionospio lighti;* the molluscs *Tellina* spp., *Axinopsida serricata* and Mytilidae juveniles; and the crustaceans *Diastylopsis* spp., *Euphilomedes carcharodonta*, and *Photis macinerneyi*. Polychaetes were the dominant taxa averaging 9,911 organisms/m^2.

For the 1996 survey, 502 different taxa were identified and the number of taxa per station averaged 132. Overall densities averaged 7,400 organisms/m^2. Polychaetes were the most abundant taxa in both surveys, averaging 9,911 organisms/m^2 in 1995 and 5,519 organisms/m^2 1996. Diversity was high, (≥ 3.50) at 38 of 39 stations. As shown in Table A-3, the three most abundant taxa within each major group included the polychaetes *Owenia fusiformis*, *Mediomastus* spp., and *Magelona longicornis;* the molluscs *Tellina* spp., *Axinopsida serricata* and *Turbonilla* spp.; and the crustaceans *Diastylopsis* spp., *Euphilomedes carcharodonta*, and *Rhepoxynius* spp. Polychaetes were the dominant taxa averaging 5,519 organisms/m^2.

Hancock (1997) summarized the information resulting from the numerous benthic studies of the offshore area of the Columbia River. Figures A-5, 6, and 7 show the station coverage that was used to summarize the information. The offshore area closely resembles the nearshore shallow water sand bottom community typical of the Oregon and Southern Washington coast. The benthic infauna (organisms which live in the sediments) are characterized by species whose evolutionary history has adapted them to high-energy environments. These environments typically contain high wave energy, which produces high fluxes of sediment deposition, erosion and transport of sand. Large storms with large waves occur off the mouth of the Columbia River which, when combined with the large fresh water output from the river and the semi-diurnal tides, produce suspended material containing both sediment and organic particulate. The bottoms of high-energy environments tend to exhibit sand waves or ripples caused by bottom transport of sand. Organisms have adapted to these high-energy environs by being highly motile (crabs, fish), rapid burrowers, quick tube builders, or rapid colonizers. Nutrients come into the offshore

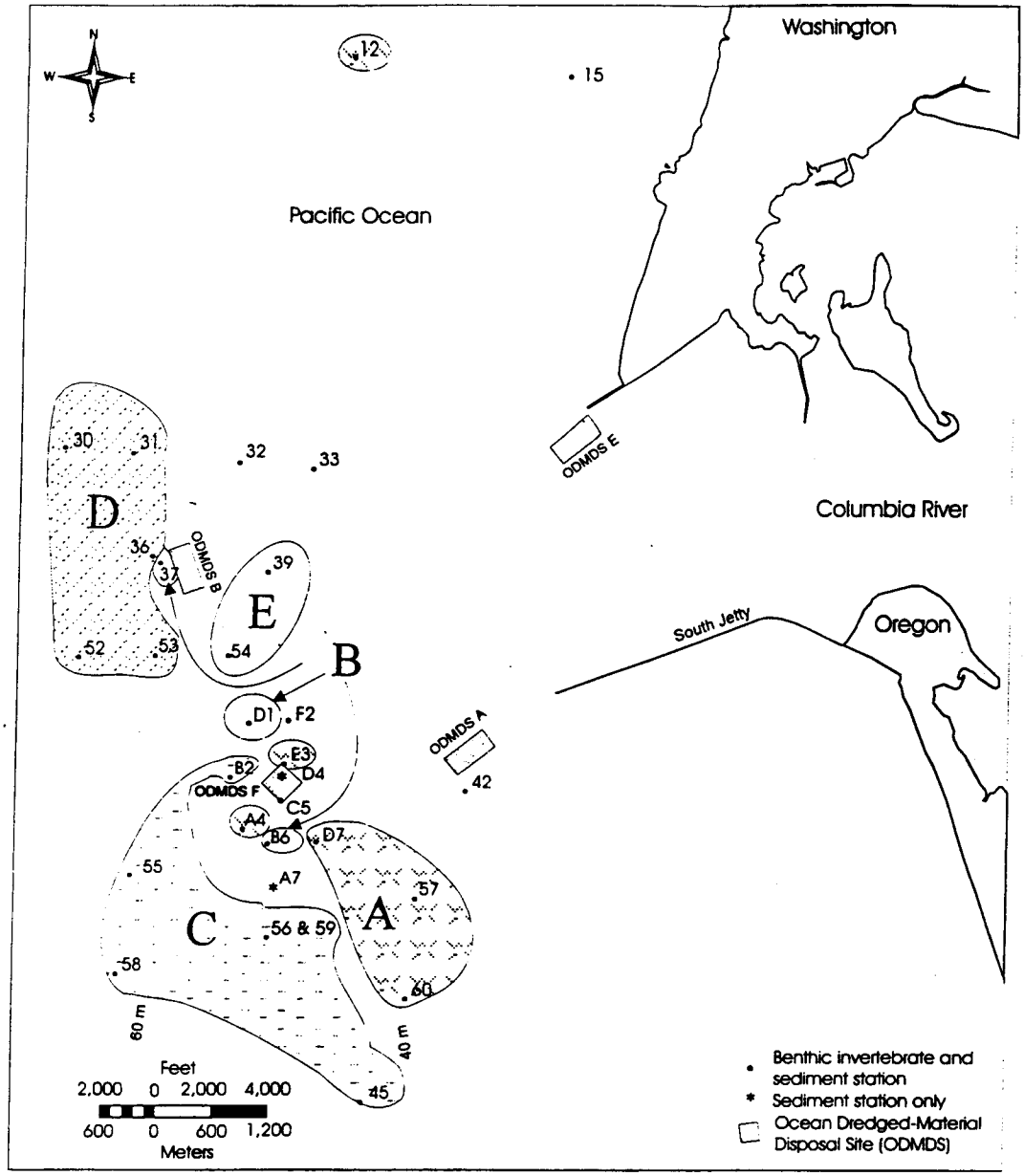


Figure A-3. Locations of benthic invertebrate cluster groups (A-E) offshore from the Columbia River, July 1993. Stations 56 and 59 were in the same location. Six stations did not cluster. (From: Emmett and Hinton, 1995).

Table A-2 -- Dominant Benthic Invertebrates, July 1993 and August 1994 (all stations)

Taxon	July 1993 mean number/m^2	August 1994 mean number/m^2
Polychaeta		
Pholoe minuta	157	113
Phyllodoce hartmanae	327	
Nephtys caecoides	160	105
Glycinde spp.	100	
Leitoscoloplos pugettensis	118	
Prionospio lighti	1,323	726
Spiophanes berkeleyorum		171
Magelona spp.	360	
Magelona sacculata		460
Pectinaria californiensis		153
Spiochaetopterus costarum	847	470
Chaetozone setosa	318	324
Mediomastus californiensis	174	313
Mediomastus spp.		108
Owenia fusiformis		3,480
Miscellaneous	893	942
TOTAL	4,777	7,262
Mollusca		
Nitidella gouldi	175	50
Olivella pycna	120	100
Olivella baetica	53	22
Olivella spp.	120	46
Acila castrensis	98	23
Mytilidae	21	95
Axinopsida serricata	127	105
Cylichna attonsa	29	
Mysella tumida		19
Tellina spp.	128	27
Macoma spp.	34	62
Siliqua spp.		278
Miscellaneous	113	91
TOTAL	1,018	917
Crustacea		
Euphilomedes carcharodonta	327	171
Diastylopsis spp.	131	2,146
Diastylopsis dawsoni	51	107
Diastylopsis tenuis	142	451
Orchomene pinquis	91	119
Photis macinerneyi		
Rhepoxynius spp.	86	100
Callianassa californiensis	43	
Rhepoxynius vigitegus	38	
Rhepoxynius abronius	34	
Leucon spp.	40	209
Caprellidea		45
Cylindroleberididae		39
Miscellaneous	356	356
TOTAL	1,339	3,743
Miscellaneous	1,635	1,164
TOTAL FOR SURVEY	8,769	13,186

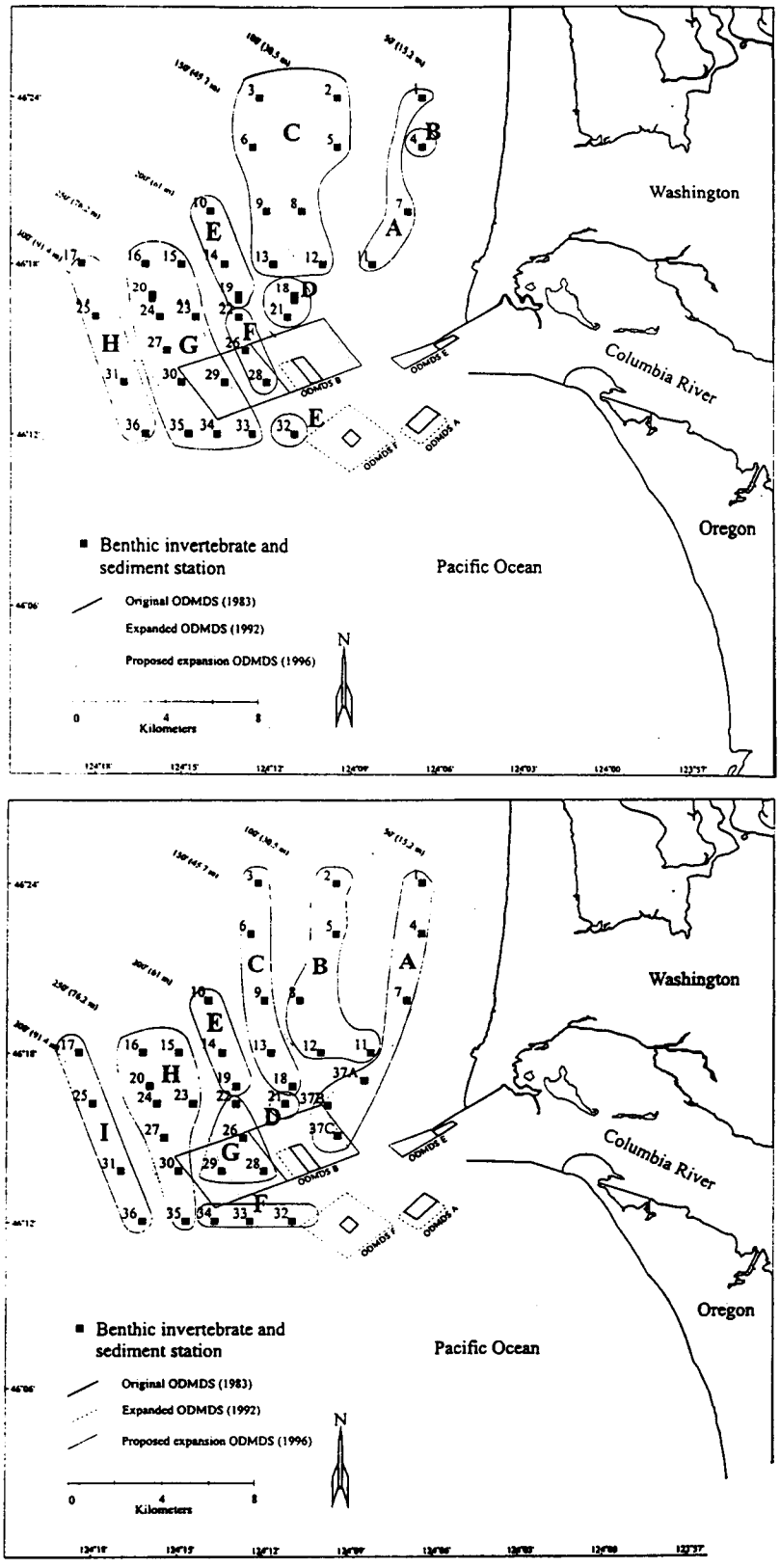


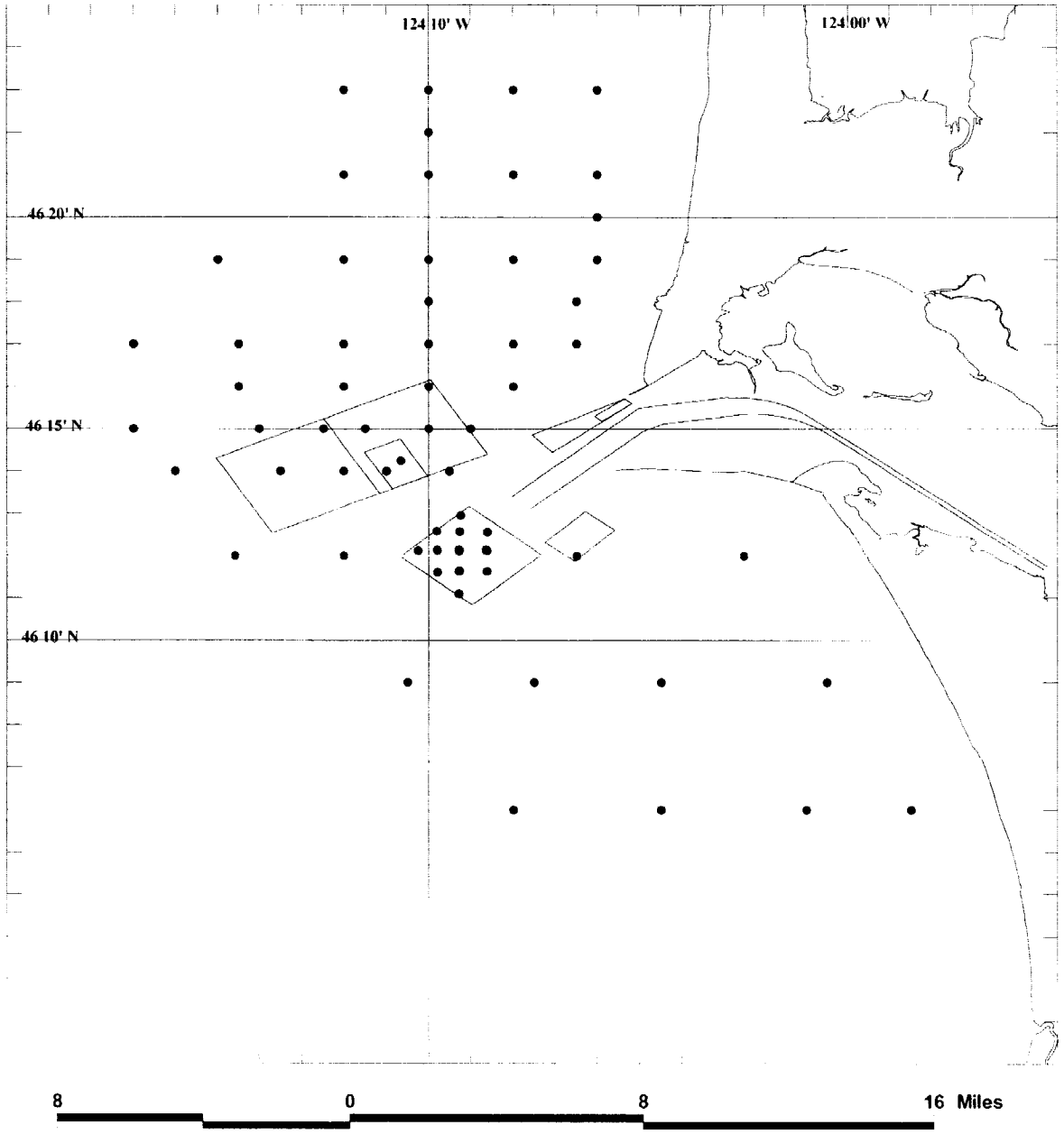
Figure A-4 locations of benthic invertebrate cluster groups (A-H) offshore from the Columbia River, October/November 1995 (top) and June 1996 (bottom). ODMDSs are Ocean Dredged-Material Disposal Sites. (From: Hinton, 1998)

Table A-3 – Dominant Benthic Invertebrates, October/November 1995 and June 1996 (all stations)

Taxon	Oct/Nov 1995 mean number/m^2	June 1996 mean number/m^2
Polychaeta		
Heteromastus filobranchus		382
Spiophanes bombyx		401
Prionospio lighti	600	212
Spiophanes berkeleyorum	209	214
Scoletoma luti	261	254
Magelona sacculata	236	
Pectinaria californiensis	318	
Galathowenia oculata	343	146
Chaetozone columbiana	315	196
Magelona longicornis	483	452
Mediomastus spp.	701	420
Owenia fusiformis	2,341	416
Miscellaneous	4,104	2,426
TOTAL	9,911	5,519
Mollusca		
Pseudopythina rugifera		27
Olivella pycna		26
Spiromoellaria quadrae	51	
Olivella spp.	32	
Astyris gausapata	37	
Mytilidae	103	14
Axinopsida serricata	300	163
Scaphopoda	23	
Mysella tumida	38	21
Tellina spp.	249	72
Macoma spp.	35	24
Nucula tenuis		14
Turbonilla spp.	25	28
Tellina modesta		14
Miscellaneous	228	131
TOTAL	1,121	534
Crustacea		
Euphilomedes carcharodonta	238	212
Diastylopsis spp.	1,265	110
Ampelisca agassizi		36
Ampelisca careyi		28
Eohaustorius sencillus	72	43
Orchomene pacifica	55	
Photis macinerneyi	111	26
Bathyleberis spp.	47	
Bathyleberis californica		44
Rhepoxynius spp.		108
Rhepoxynius vigitegus		26
Rhepoxynius abronius	40	
Rhepoxynius daboius	105	
Rhepoxynius tridentatus	75	26
Americhelidium millsi	32	
Miscellaneous	462	397
TOTAL	2,502	1,056

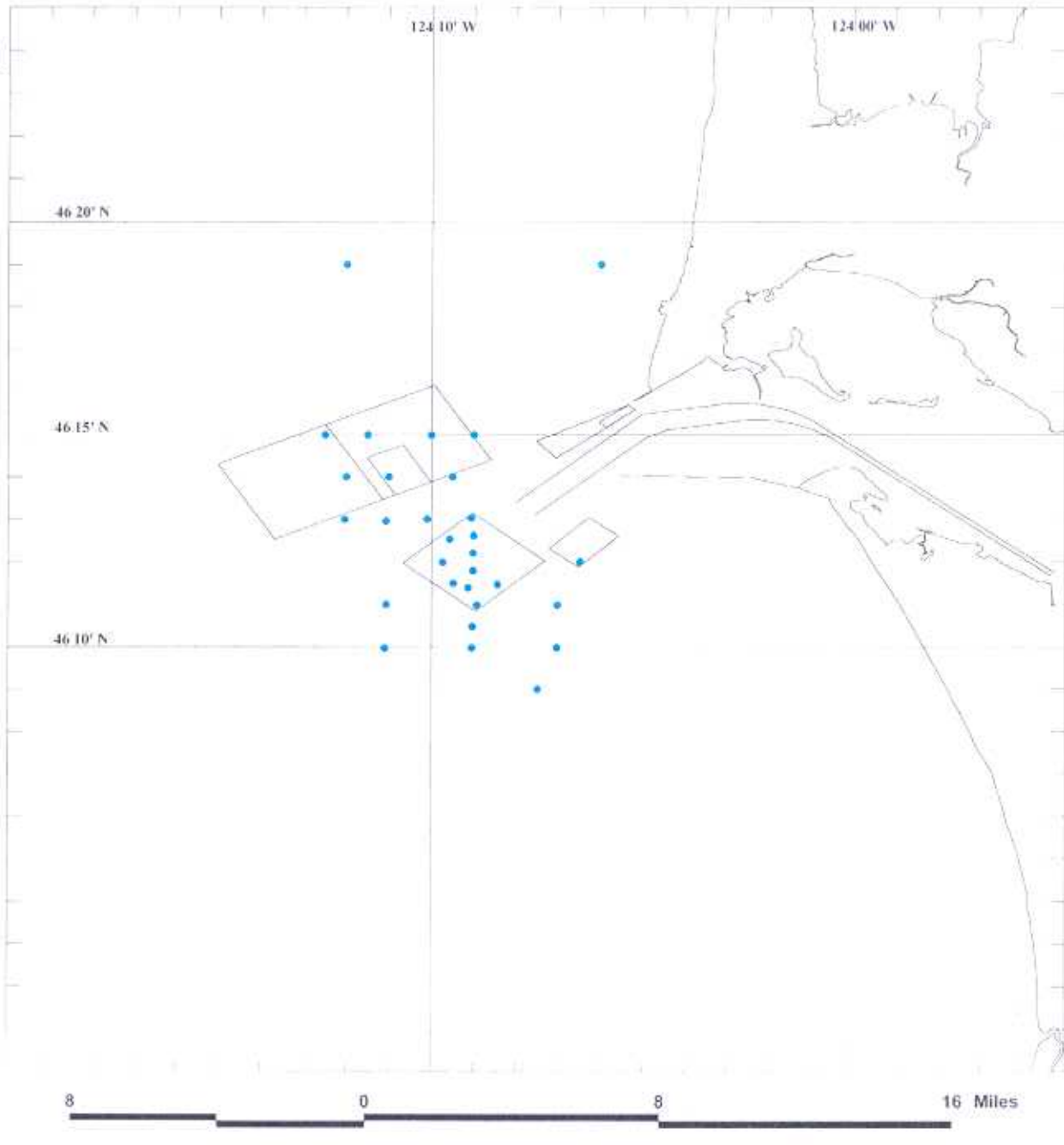
1992 Benthic Infauna Sample Locations

Figure A-5



1994 Benthic Infauna Sample Locations

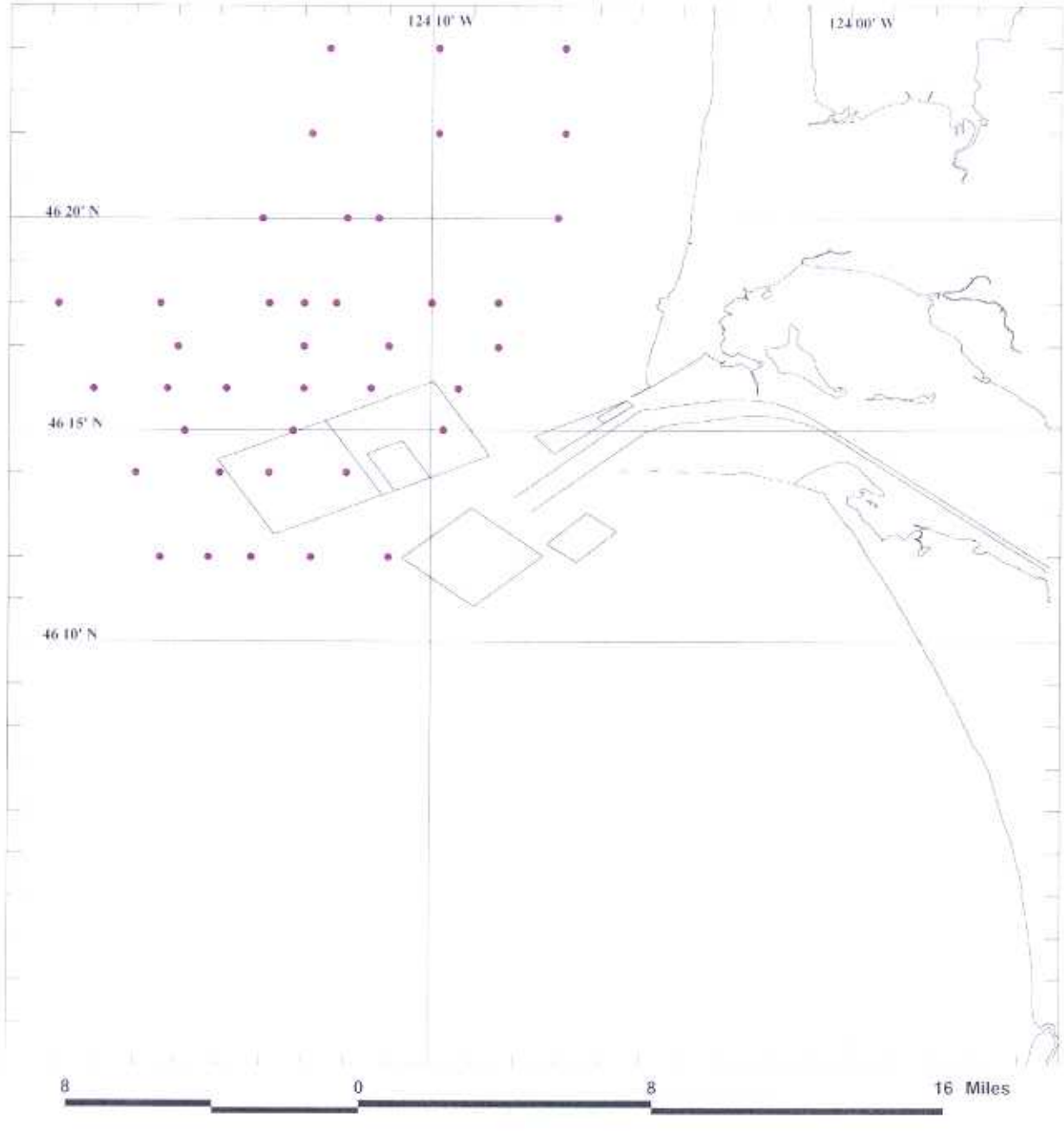
Figure A-6



- Hinton & Emmett 94-1996
  Columbia River mouth basemap

1996 Benthic Infauna Sample Locations

Figure A-7



system from rivers ("outwelling"), from the deep ocean ("upwelling"), and from the surface ("downwelling").

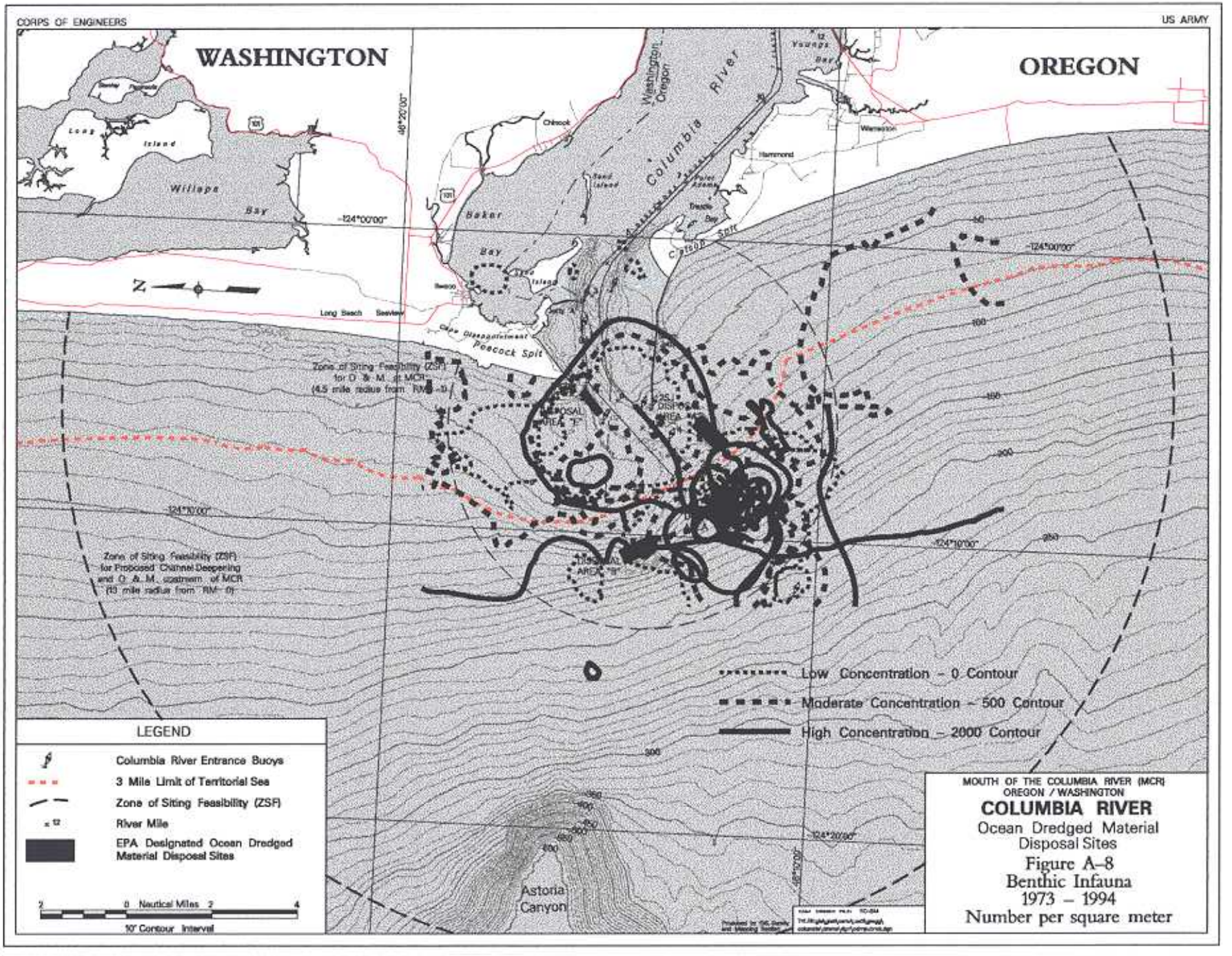
With one exception, the nearshore wave swept zone exhibits the lowest densities, seasonal variability and patchiness. The exception was in 1994, when the nearshore shallow water stations exhibited both the highest and lowest density. The two shallow water stations with the highest densities (stations #39 and #54) were low in diversity and dominated by two species, *Diastylopsis* spp. (very mobile cumaceans) and *Owenia fusiformis* (an opportunistic polychaete). These species are rapid colonizers and highly tolerant of disturbed areas caused by currents, wave surges and shifting sediments. The studies reviewed, however, indicate that in general, invertebrate densities increased with distance from shore. The nearshore shallow water benthos tends to have fewer taxa and lower densities than quieter offshore habitats especially in areas with sediments of finer grain size and higher organic content.

The combined results of the studies indicate the benthic assemblages in the offshore area exhibit community patchiness, year-to-year variations in density and species composition, seasonal variability and responses to disposal impacts. A map incorporating the densities of benthic infauna in the offshore area from study efforts is shown in Figure A-8. Such characteristics of the benthic infauna are typical of areas of high disturbances and the species found in these habitats tend to be rapid colonizers, high-energy tube dwellers, and rapid burrowers. Variations in the densities of benthic infauna as reported in the individual studies reviewed are consistent with observations reported from other high-energy nearshore shallow sandy environments.

Sandy shallow water marine systems typically exhibit larger spatial and temporal variations than deeper water low energy areas, which tend to have more stable hydrography. The lessening of wave and current action allows finer grained sediments to settle and produces muddier bottoms.

Two kinds of fluctuations-are reported in the studies, sudden increases in the abundance of one or two species at a single or a few stations, and fluctuations in the overall trends in populations (in abundance or density) at most stations throughout the area. The sudden increases between station or seasonal variations which were reported on several occasions can be correlated with natural population fluctuations such as mass recruitment. For example, in 1992 some of the highest densities ever observed in Oregon and Washington were found. A large set of juvenile razor clams were responsible for the high values. In 1994 *Diastylopsis* spp. (very mobile cumaceans) and *Owenia ,fusiformis* were found to produce a very high density at two inshore stations which normally have lower density than the offshore sites. Bottom disturbances are thought to create microhabitats which allows these opportunists to invade momentarily.

The trending type of population fluctuations, such as seen by making overall comparisons over several years generally reflect changes in natural oceanic conditions. All studies seem to indicate population fluctuations in the benthic infauna resulting from changes in primary productivity brought about from oceanic conditions such as upwelling, downwelling, and


CORPS OF ENGINEERS
US ARMY
WASHINGTON
OREGON
Columbia River
Washington
Oregon
Willapa Bay
Long Island
Baker Bay
Sand Island
Chinook
Ilwaco
Long Beach Seaview
Cape Disappointment
Peacock Spit
Chinook Spit
Point Adams
Hammond
Warrenton
Astoria
Youngs Bay
Desdemona Sands
Zone of Siting Feasibility (ZSF) for O & M at MCR (4.5 mile radius from RM 0)
Zone of Siting Feasibility (ZSF) for Proposed Channel Deepening and O & M, southern of MCR (10 mile radius from RM 0)
DISPOSAL AREA "B"
DISPOSAL AREA "A"
DISPOSAL AREA "C"
Astoria Canyon
-124°00'00"
-124°10'00"
-124°20'00"
46°20'00"
46°10'00"
Low Concentration – 0 Contour
Moderate Concentration – 500 Contour
High Concentration – 2000 Contour
LEGEND
Columbia River Entrance Buoys
3 Mile Limit of Territorial Sea
Zone of Siting Feasibility (ZSF)
River Mile
EPA Designated Ocean Dredged Material Disposal Sites
2 0 Nautical Miles 2 4
10' Contour Interval
MOUTH OF THE COLUMBIA RIVER (MCR)
OREGON / WASHINGTON
COLUMBIA RIVER
Ocean Dredged Material Disposal Sites
Figure A–8
Benthic Infauna
1973 – 1994
Number per square meter

outwelling which brings nutrients. In addition, large storm events and spring freshets as well as site-specific disposal of dredged material introduce variability and seasonal change.

Although the studies of actual disposal of dredged material show a decline in infaunal populations immediately after disposal, rapid recovery and repopulating occurs. Recovery from disposal impacts for benthic invertebrates and Dungeness crab appears to begin after disposal and often exhibits higher densities within a year. The recovery levels of benthic invertebrates often exceed the pre-disposal conditions because the disturbed area is invaded by opportunistic species, which are highly mobile or otherwise adapted to colonizing disturbed areas.

The relationship between benthic infauna, macrofauna and fish is evident through many food habit studies. Benthic invertebrates are important prey for many species of demersal fish and shellfish, especially juveniles, which are abundant off the Columbia River and the central Oregon Coast (Durkin and Lipovsky, 1977; Pearcy and Hancock, 1988). The increase in demersal fish and shellfish densities corresponds with the observed overall increase in benthic invertebrate densities from 1989 to 1992 in the offshore area.

The general sediment characteristics in the area are quite uniformly a fine grained sand. However, the studies consistently found a lobe of finer grained (silt) sediments trending to the west and northwest of disposal site "B" toward Willapa Submarine Canyon. The studies also indicate both annual and diurnal transitory fine-grained deposits occur in the offshore area particularly near the river mouth. Based only on infauna, the area of finer sediments lying west and northwest of disposal site "B" has been identified as dissimilar from the rather uniform sandy bottom area found throughout the rest of the area. The finer sediments and different species components were identified consistently throughout the study efforts.

Epibenthic Invertebrates

Epibenthic invertebrates collected off the mouth of the Columbia River were also divisible into assemblages (Richardson, et al., 1977). Group A was predominantly from inshore stations and was dominated by shrimp (*Crangon alaskensis elongata*, *C. stylirostris*, and *C. franciscorum*), Dungeness crab (*Cancer magister*), and the mysid *Neomysis kadiakensis*. Group B was located offshore south of the south jetty, and had a low abundance with few species. The most abundant species was the shrimp *C. stylirostris*. Group C was located in the southern portion of the area at intermediate depths (35 to 73 m). Numerically dominant species included shrimp (*C. alaskensis elongata*, *Pagursus ochotensis*, and *Nectocrangon alaskensis*), a mysid (*N. kadiakensis*), and a brittle star (*Ophiura lutkeni*). Group D was from deeper water (80 to 90 m); the brittle star *0. lutkeni* and the shrimps *Pandalus jordani*, *C. alaskensis elongata*, *C. communis* were most abundant. Other common species included the brittle star *0. sarsii*, the mysid *N. kadiakensis*, and the decapods *Spirotocaris avinia* and *Thysanoessa spinifera.*

Of the epibenthic species that occur off the mouth of the Columbia River the Dungeness crab (*Cancer magister*) is one of the most important commercial species. Dungeness crabs

occur along the West Coast from Alaska in the north, to Magdalena Bay, Mexico in the south, though they are not very abundant south of Point Conception, California. Crabs occur from the intertidal areas of the estuaries to a depth of at least 600 feet in sediment types ranging from mud to sand. Five separate groupings in California and one or possible two in Oregon and Washington have been identified based on productive crabbing grounds. None of these groups are genetically distinct since recruitment occurs into the groups from the entire coastal population.

Crabs are highly mobile and, though most only move a few miles movements up to a 100 miles have been documented. Tagging studies done on coast wide crab populations have shown no consistent pattern in their movement but adults and juveniles do not seem to move between the various coastal grouping to any extent. Crabs generally move inshore in the spring and summer and offshore in the fall and winter they also move in and out of bays and estuaries and between bays. Young of the Year (YOY) crabs in particular move into the bays and estuaries in the spring to rear. Most of the adult and juvenile movements appear inconsistent but are probably based on a response to localized environmental conditions. There is no indication on what percentage of the population makes these movements (PFMC, 1979).

Adult crabs occur on a variety of substrate types but generally prefer a sand mud bottom. Young of the Year and young juveniles prefer beds of eelgrass or areas of shell hash either as protection from predation or for the abundance of food organisms on these substrates. Larger juveniles and adults do not show a preference for cover and can be found on most bottom types and even up into the littoral areas at high tide feeding (Pauley et al. 1986). Dungeness crab are reasonably tolerant of salinity and temperature and have been collected in both Grays Harbor, WA and the Columbia River estuary from brackish water to ocean water. Temperature preference of crabs differs by season but they generally prefer temperatures in the range of 3-19 ^{o}C. Tolerance of lower salinity seems to decrease as crabs get older.

Dungeness crab mate during spring months in Washington and northern Oregon. Mating occurs offshore between a soft shelled female and a hard shelled male. After copulation the sperm is sealed in the female and remains alive for several months until eggs are fertilized and extruded. This typically occurs in mid to late fall in Oregon and Washington. After fertilization the eggs are attached to the swimmerets of the abdominal segment of the female forming a sponge like mass. Females can carry from 500,000 to 2.5 million eggs depending upon the age of the female. Eggs hatch in the nearshore area typically from late December to early February, though a smaller amount of hatching may occur throughout the winter into the spring. Crab larvae are planktonic and they develop throughout the winter passing through five zoeal and one megalops stages. In the spring they drift or are carried inshore on other drifting organisms and settle out of the plankton after the final stage of their larval phase. Megalops metamorphose to first post larval stage and then molt into YOY crabs in April to May in Oregon and Washington, but may occur later in some years. The first post-larval stage is bottom dwelling and ranges from 6-7mm in size when they settle to the bottom.

Crabs grow by molting, a process by which their existing hard shell is shed and replaced by a larger soft shell. Juvenile crabs molt several times a year during their first or second year of life and normally once a year thereafter until they reach legal harvest size at four years of age. After this they grow more slowly and may not molt each year. This is particularly true for females, which may not molt annually.

Crabs are opportunistic feeders and will eat almost any organism on or in the substrate. Food items consist primarily of other crustaceans, mollusks, fish, echinoderms and polychaetes. They are also cannibalistic and will prey on other crabs particularly in the soft shell state. A wide variety of organisms prey on Dungeness crabs. Coho salmon and to a lesser extent spring chinook, feed heavily on crab larvae and megalops, Other fish species including sculpins, rockfish, wolf-eels, lingcods, flatfish, croakers, sturgeon, greenling, cod, hake, and salmon as well as other crabs, octopus, and the giant starfish prey on adult crabs.

Dungeness crab population numbers are subject to large cyclic fluctuations in abundance. Even though catch records for some species can vary due to factors that don't have any connection with the population numbers, the catch records for the Dungeness crab fishery are generally believed to represent actual population fluctuations (Higgins et al., 1997). This is due primarily to the large fishing effort and exploitation rate of the fishery. Studies on the causes of these fluctuations in population numbers have been inconclusive. Crabs have a complex life cycle that is influenced by a variety of environmental factors that may or may not be related to population numbers. These factors make it difficult to predict survival and year class strength. In central California the most significant factors affecting crab population numbers was uncorrected sea level and atmospheric pressure, while in northern California sea surface temperatures and density of the crabs themselves were the most important. Predicting population numbers of crabs has been at best speculative in the past. Recent modeling efforts by Higgins et al (1997) have proved promising in identifying the effect various factors have on population levels. The model combines both crab density driven control of the population with small scale environmental variables to predict crab population numbers. The model has shown that these small scale environmental changes, such as a delay in the inshore currents in the spring by a short period of time, can dramatically impact survival of the young of the year crab but have no effect on adults and older juveniles inshore. Crab population levels based on landings data from Washington coast have had lows in 1981-2 and 1991 and highs in 1988-9 and in 1995 (the most current available data). Since it takes crabs four years to grow to a harvestable size, the impact to the population would have occurred four years prior to the landings numbers.

Crab population trends off the mouth of the Columbia River then, can be approximated by using landing data from the Ports of Astoria, Oregon and Ilwaco, Washington. Most of the fisherman that land crabs at these ports have fished in the area offshore of the MCR. Landing data was obtained from Hoines (1998) for Washington and from Lucas and Carter (1998) for Oregon. As indicated below in Figure A-9 peak population levels occurred in 1989 and again in 1995 while population lows occurred in 1985 and in 1991. A comparison with coast wide landings shown in Figure A-10 shows a similar trend for both total Oregon and total Washington Dungeness crab landings. The reasons for the decline in

1991 and the increases in 1989 and 1995 is unknown, however the factors effecting crab abundance were occurring coast wide in Oregon and Washington since the population trends are similar for total coastal landings.

Figure A-9 Dungeness Crab Landings at the Mouth of the Columbia River by Year.

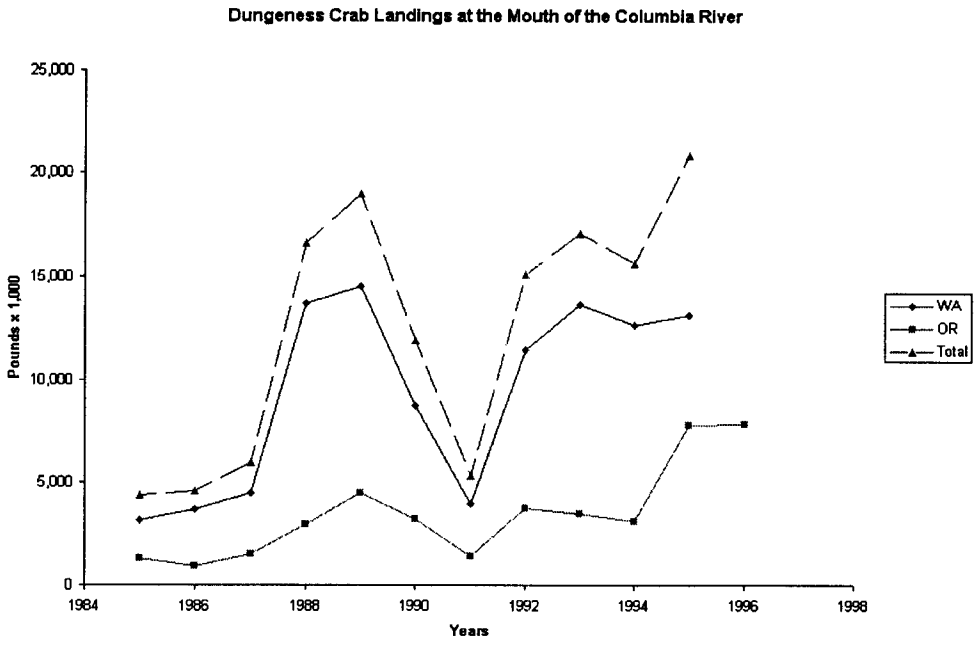
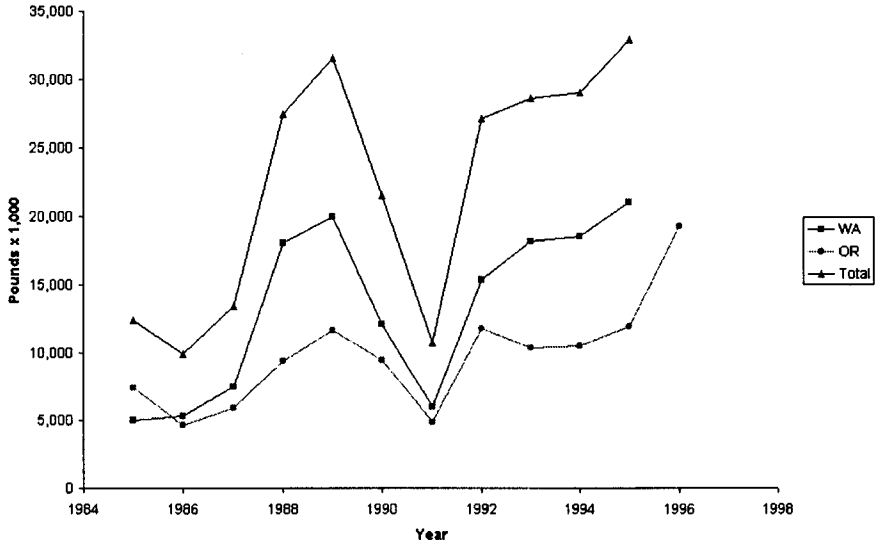


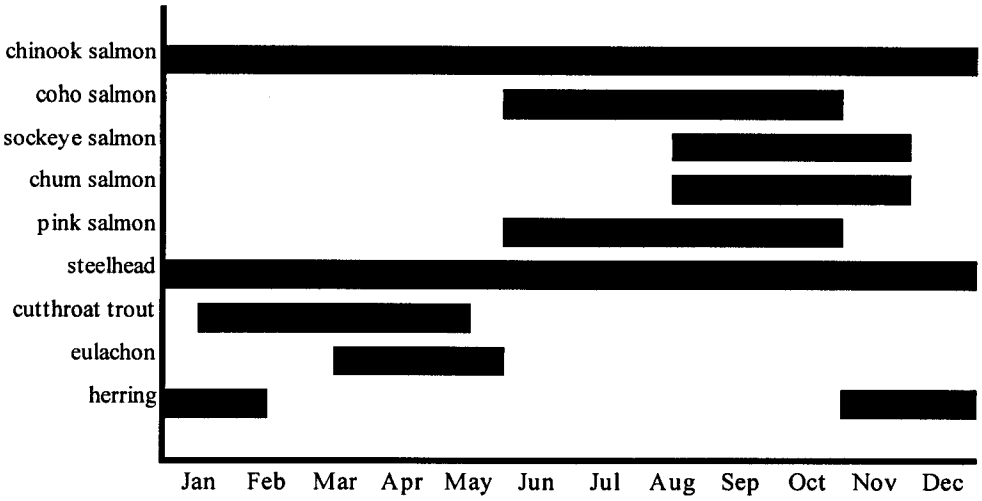
Figure A-10 Dungeness Crab Landings for all Oregon and Washington Ports by Year.



Fisheries

A variety of both anadromous and resident fish species occur as both adults and juvenile stages within the offshore area of the Columbia River. Anadromous species such as salmon, steelhead, shad, lamprey, smelt, herring and sturgeon are present in the area as adults prior to migrating to spawning grounds in the estuary or upstream in the Columbia River. Juveniles of these species are present in the area following their migration out of the river or estuary into the ocean. Some remain in the near inshore area for various periods of time feeding and rearing, while others move directly offshore. (Figure A-11).

Figure A-11 – Periods of Occurrence of Adult Migrating Fish at the Mouth of the Columbia River



Resident species occur in the offshore area throughout the year with many using the estuary as a rearing and nursery area. Species present include various species of flatfish, rockfish and other demersal species.

Durkin and Lipovsky (1977) performed a detailed analysis of the demersal fish species collected in the offshore area of the Columbia River between October 1974 and April 1976. Fifty-one species of fish were collected of which 11 represented 95 percent of the total catch (Table A-4).

Table A-4 – Major Fish Species, 1974-1976 (Durkin and Lipovsky, 1977)

Species	Primary Habitat	Percent Total
Northern anchovy	Pelagic	47.06
Night smelt	Pelagic	8.99
Butter sole	Demersal	8.07
Whitebait smelt	Pelagic	6.91
English sole	Demersal	6.11
Pricklebreast poacher	Demersal	4.71
Pacific tomcod	Demersal	3.80
Osmeridae larvae	Pelagic	3.37
Showy snailfish	Demersal	2.76
Pacific sanddab	Demersal	1.93
Eulachon	Pelagic	1.26

Hinton et al., (1992) conducted pre- (June 1989) and post-disposal (June 1990) demersal fish surveys at and adjacent to the Corps' Ocean Dredge Material Disposal Site F, which is offshore from the mouth of the Columbia River. Three bottom trawling efforts were conducted during each survey. Trawling depths ranged from 36.3 to 45.1 meters. The major fish species captured during the surveys are shown in Table A-5.

According to Durkin and Lipovsky (1977) and Bottom, et al., (1984), there are generally two fish species assemblages in the offshore area: one north of the Columbia River mouth and one south. The northern assemblage includes anchovy, white bait smelt, longfin smelt, Pacific tomcod, pricklebreast poacher, and showy snailfish. The southern assemblage includes the shiner perch, Pacific staghorn sculpin, Pacific sanddab, butter sole and sand sole.

Table A-5 – Major Fish Species, 1989 and 1990 (Hinton et al., 1992)

Species	June 1989 Mean number per hectare	June 1990 Mean number per hectare
Whitebait smelt	2,963	7,905
Pacific tomcod	212	158
Pacific sanddab	326	147
Butter sole	271	268
English sole	184	214
Northern crangon	422	294
Miscellaneous	442	620

Northern anchovy are an important food fish for other fish and were present from November to January. They were predominantly juveniles, ranging in size from 48 to 148 millimeters (mm). They occurred in different water levels depending upon their age, food preference and the season. Anchovy feed predominantly upon phytoplankton.

White bait smelt are also an important food fish. They are common from spring until mid-autumn, ranging in size from 42 to 145 mm and included several discernable size groups from juvenile to adult. White bait smelt feed upon cumaceans, copepods, small mysids and anchovies.

Longfin smelt, another important food fish, are common during winter and spring. They ranged in size from 43 to 135 mm and, though no definite size groups were apparent, juveniles were most abundant from July to August. Longfin smelt feed predominantly on zooplankton, though the type changes with the season.

Pacific tomcod ranged in size from 27 to 300 mm. Two definite age groups were present until July, and only one after that. Tomcods are common from August to November. Tomcod feed predominantly on cumaceans, amphipods, shrimp and fish.

Pacific staghorn sculpin are abundant in most coastal areas. Those collected were adults, ranging in size from 65 to 126 mm. They feed on shrimp and fish. Picklebreast poacher are abundant from spring to September. Several size groups were distinguishable, ranging in size from 27 to 160 mm. Picklebreast poacher feeds predominantly on mysids. Showy snailfish occurr from August to December with peak catches in August and September. Several size groups were apparent with the young entering the catch from April to May. Individuals collected ranged in size from 18 to 124 mm and were most dominant directly off the mouth of the Columbia River. While showy snailfish consume polychaetes and amphipods in winter and spring, they consume crangon shrimp year-round.

Most of the flatfish collected are commercially or recreationally important species. The Pacific sanddab are common in May, June, and September with the young of the year entering the catch in the spring. They ranged in length from 34 to 345 mm. Sand sole were collected all year except during June and July. Sizes ranged from 45 to 555 mm. Both sand sole and Pacific sanddab consume large shrimp and/or anchovies.

Butter sole are present most of the year, though larger fish leave during the winter. Fish ranged in size from 30 to 375 mm with the young of the year entering the catch in May. Most butter sole were collected off the river mouth. English sole, one of the most important commercial species, are most common from May to November and were fairly evenly distributed over the sampling area. The individuals collected ranged in size from 20 to 400 mm and showed distinct size and age groups. English and butter soles feed on cumaceans, amphipods, shrimp, juvenile razor clams and, in summer, fish and polychaete worms.

Juveniles of the migratory species appear at various times of the year. Some species migrate immediately into the ocean, while others rear in the estuary or immediately offshore for varying lengths of time. Miller et al., (1983) investigated the distribution of juvenile steelhead and coho and chinook salmon off of the Oregon coast. Peterson et al., (1982) described their dominant food items as euphausids, hyperiid amphipods, crab larvae, and fish.

In general, steelhead juveniles move rapidly out of the offshore area and were only present during the May-June sampling period (Miller et al., 1983). Chinook salmon also appear to move offshore since numbers were high during the first cruise and low during the second. Numbers increased again during the August to September cruise. This may indicate recruitment for the inshore area. Coho salmon Juveniles were generally uniformly distributed and appeared in equal numbers during the first and third sampling periods. The general decline in both chinook and coho salmon numbers during the second cruise, though possibly an outmigration, also may have been due to the higher than normal water temperature. This may have caused the fish to move into deeper waters, thereby avoiding the purse seine.

Occurrence of adult migratory species off the Columbia River is correlated primarily with their spawning period. Although some species such as coho salmon may spend large portions of their lives in the offshore area, the actual residence time has not been determined. A list of the migratory species and the adult period of occurrence based on spawning times is shown in Figure A-12.

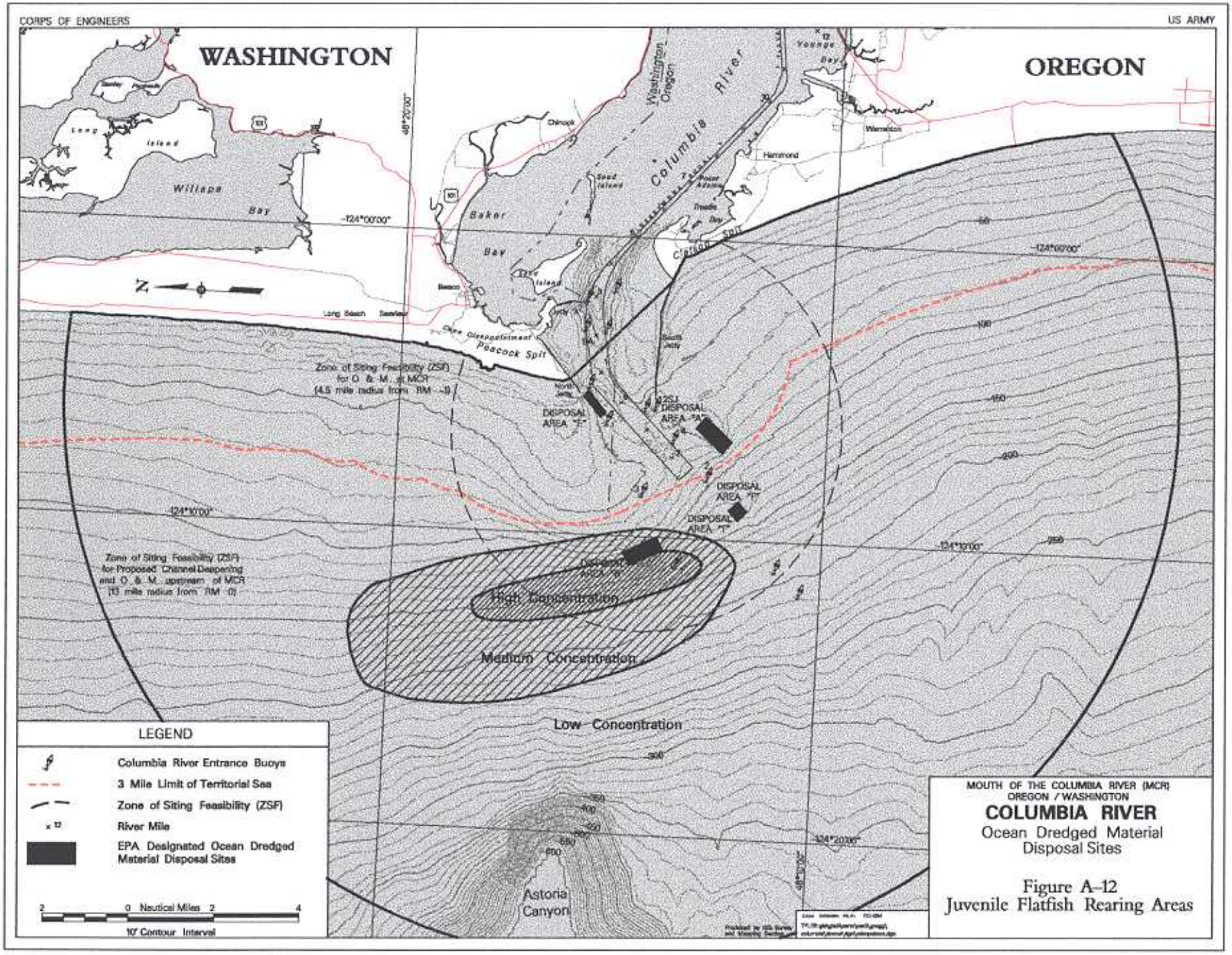
Marine Mammals and Sea Turtles

Potentially 30 cetacean species can occur along the Oregon coast (Green et al., 1989) although their numbers are generally limited. Most cetacean species observed by Green et al. (1991) occurred in slope (600- to 6,000-foot depths) or offshore waters (greater than 6,000 feet deep). Harbor porpoises and gray whales were prevalent in shelf waters less than 600 feet deep. The larger cetaceans (whales) typically occur as migrants. The most prominent example is the California gray whale. Essentially, the entire population of approximately 21,000 animals migrates through the offshore areas (Breiwick et al., 1988). Southbound gray whales are present from November to early February; the northward migration begins in mid-February and extends until May. Gray whales migrate from their breeding grounds at Baja, California to their principal foraging grounds in the Beaufort, Chukcki, and Bering seas.

Populations of other cetaceans generally are considerably less abundant that the gray whale. Smaller cetaceans, principally dolphins, porpoises, and some small whales are also present. Killer whales and harbor porpoises are the more commonly known representatives of the smaller cetaceans present. Occurrence of other species is typically from late spring to early fall, usually as migrants.

Four species of marine turtles, loggerhead, green, Pacific ridley, and Pacific leatherback, have been recorded from strandings along the Oregon and Washington coastline since 1982 (Green et al., 1991). Marine turtles are unusual in their occurrence along the Pacific Coast and are typically associated with warmer marine waters than occur off the Oregon and Washington coasts.

Five species of pinnipeds are known to occur along the Oregon coast: northern sea lion, California sea lion, harbor seal, northern elephant seal and northern fur seal (Bonnell et al.,


CORPS OF ENGINEERS
US ARMY
WASHINGTON
OREGON
Willapa Bay
Long Island
Baker Bay
Columbia River
Washington
Oregon
Chinook
Hammond
Warrenton
Astoria
Peacock Spit
Clatsop Spit
Zone of Siting Feasibility (ZSF) for O & M upstream of MCR (4.5 mile radius from RM -1)
Zone of Siting Feasibility (ZSF) for Proposed Channel Deepening and O & M upstream of MCR (13 mile radius from RM 0)
DISPOSAL AREA "F"
DISPOSAL AREA "A"
DISPOSAL AREA "B"
DISPOSAL AREA "T"
DISPOSAL AREA "S"
High Concentration
Medium Concentration
Low Concentration
Astoria Canyon
-124°00'00"
-124°10'00"
-124°20'00"
46°20'00"
46°10'00"
LEGEND
Columbia River Entrance Buoys
3 Mile Limit of Territorial Sea
Zone of Siting Feasibility (ZSF)
River Mile
EPA Designated Ocean Dredged Material Disposal Sites
2 0 Nautical Miles 2 4
10' Contour Interval
MOUTH OF THE COLUMBIA RIVER (MCR)
OREGON / WASHINGTON
COLUMBIA RIVER
Ocean Dredged Material Disposal Sites
Figure A–12
Juvenile Flatfish Rearing Areas

1991). Harbor seals are resident whereas the four other species of pinnipeds are more transient in nature (Bonnell et al., 1991). Harbor seals, California sea lions and northern sea lions are the principal species observed in the estuary. All three species are known to forage within the Columbia River estuary and adjacent ocean waters. It was estimated that about 200 to 225 California sea lions and approximately 50 northern sea lions occur in the Columbia River estuary region (Fox et al., 1984). There are an estimated 6,000 to 7,000 harbor seals in the estuary region (Jeffries, 1986). Significant numbers (1,000 to 1,500) of harbor seals occur in the estuary, particularly during the smelt run in February and March (Jeffries et al., 1984). Peak numbers are present from December through April and decline thereafter for the pupping season (Jeffries et al., 1984). Desdemona Sands near Astoria is a principal haulout area for harbor seals in the estuary.

Avifauna

Pelagic birds are extremely numerous in the offshore area of the Columbia River. Briggs et al., (1992) found that seabird populations were most densely concentrated over the continental shelf (less than 600 feet in depth). Shearwaters, storm petrels, gulls, common murres and Cassin's auklets numerically dominated the pelagic bird fauna from late spring through late summer. Phalaropes, fulmars and California gulls are important constituents of the fall pelagic bird flocks. The principal species or species groups in the winter pelagic bird population are phalaropes, California gulls, fulmars, other gulls, murres, auklets, and kittiwakes (Briggs et al., 1992).

Red-throated, Pacific and common loons occur as spring and fall migrants. Red-throated and common loons have been observed during winter in the Columbia River estuary and immediately offshore. Pacific loons occur during migration. Loon species are generally most abundant in the lower estuary but also occur throughout the entire reach of the estuary and upstream.

Western, red-necked, horned, and eared grebes occur in the area. Western grebes are the most abundant grebe and occur throughout the estuary, particularly in the bays and offshore during migration and in winter. Red-necked, horned and eared grebes occur as migrants and are generally present in the estuary or near shore ocean areas.

Brown pelicans occur from late spring to mid-fall along the Oregon Coast. Concentrations of this species develop at the mouth of the Columbia River at the South Jetty and at East Sand Island-Baker Bay. This species forages in nearshore waters of the Pacific Ocean and estuarine waters of the Columbia River. Concentrations up to 1,000 birds have been reported (Briggs et al., 1992).

Three species of cormorants occur and forage in nearshore Pacific Ocean waters and the Columbia River estuary. Double-crested cormorants are the most numerous. This species occurs all year throughout the estuary, nearshore waters, and upstream. Pelagic cormorants nest on the cliffs at Cape Disappointment and forage in the lower estuary. Brandt's cormorants generally occur at the mouth and offshore, and nest at Cape Disappointment.

Briggs et al., (1992) reported nine gull species (Bonaparte's, Heermann's, California, herring, Thayer's, western, glaucous-winged, and Sabine's gulls plus black-legged kittiwake) along the Oregon and Washington coasts. Three other species known to occur are glaucous, mew and ring-billed gulls. Gull species occur throughout the area with concentrations in the estuary around nesting islands and offshore.

Three species of terns occur over nearshore waters. Caspian terns are present from April to September and occupy a large breeding colony of about 8,000 pairs at river mile 21 at Rice Island (Roby et al., 1998). The Caspian tern colony at Rice Island is the largest in North America and potentially the world (Roby et al., 1998). Foraging by Caspian terns occurs throughout the estuary, although they are concentrated below Crims Island. Common and Arctic terns occur off the Oregon and Washington coasts from April to September with peak counts in June and September (Briggs et al., 1992). Migrant common terns have been observed in the lower estuary.

Threatened and Endangered Species

The federally listed threatened and endangered species which may occur in the vicinity of the ocean dredged material disposal locations include: blue, finback, sei, right, hump-backed and sperm whales; loggerhead, green, Pacific ridley, and Pacific leatherback sea turtles; northern (Steller) sea lion; marbled murrelet; bald eagle; Aleutian Canada goose; peregrine falcon; and brown pelicans. These species vary in season and location of occurrence within the offshore area. All of the listed stocks of salmonids occur off the MCR either as adults migrating upstream or as juveniles migrating out to the ocean. None of the area being evaluated for a new ocean disposal site is critical habitat for any of these stocks. Consequently they will not be impacted by any site selected.

The six-listed whale species occur in the Pacific Ocean and are infrequent visitors to the offshore area. Whales are not known to congregate for foraging or other uses off the mouth of the Columbia River. The four species of sea turtles listed occur only incidentally along the Oregon and Washington coastlines. They are normally associated with warmer ocean waters.

Northern sea lions are know to forage at the Columbia River mouth, in the estuary and river proper, and immediately offshore plus travel through the area. The Columbia River south jetty is a known haulout area for Northern sea lions. Ample habitat exists in the Columbia River estuary and offshore areas away from project-related actions for northern sea lions to forage or pursue other activities. Dredging and disposal would primarily occur in summer and early fall whereas northern sea lions are more prevalent in winter. This timing difference would also lessen the potential for any conflicts.

Marbled murrelets occur in nearshore waters and nest inland in old growth coniferous forests. A few individuals are occasionally observed at the mouth of the Columbia River. The species is present in only low numbers because substantial stands of old growth coniferous forest inland along the lower Columbia River no longer exist. Ocean disposal of

dredged material would be typically located further offshore than this species generally occurs.

Wintering and breeding populations of bald eagles occur in the vicinity. Bald eagles are principally associated with the Columbia River and adjacent lands. Offshore use by this species has not been noted. Aleutian Canada geese probably migrate through this general area but stopover by these birds is infrequent, if at all. The peregrine falcon is both a migrant and a winter resident in the Columbia River estuary. Foraging by this species may occur in the area but this species is principally expected to occur within the confines of the estuary. Brown pelicans occur in the area from June through October. Numbers vary annually from a few to approximately one thousand birds. Foraging occurs in nearshore and estuarine waters, with northern anchovies being an important prey species. Disposal could result in occasional localized disturbance to these species foraging offshore or in the estuary. However, numerous areas are available to foraging in the vicinity of the proposed sites.